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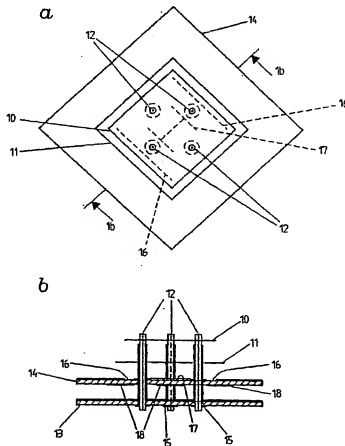
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(54) Title: ANTENNA ARRANGEMENT

## (57) Abstract

The present invention relates to an antenna arrangement for multipfrequency band operation which makes it possible to reduce the number of antennae on a base station antenna mast. The antenna comprises a first radiator element (10) for operation in a first frequency band and a second radiator element (11) for operation in a second frequency band. The second element is arranged in a different plane from said first element. The first element (10) is placed so that it symmetrically overlaps the second element (11). A conductive ground plane (13; 14) is provided with means for feeding energy to the radiator elements, and that the radiator elements are arranged for providing dual polarization. The invention also relates to an array antenna arrangement comprising groups of high and low frequency elements.



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## Title

## ANTENNA ARRANGEMENT

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## FIELD OF THE INVENTION

The present invention relates to an antenna arrangement for multi frequency band operation, comprising a first radiator element for operation in a first frequency band and a second radiator element for operation in a second frequency band, wherein said second element is arranged in a different plane from said first element. The invention also relates to an array antenna arrangement comprising groups of first and second elements. Also, the invention relates to the use of such an antenna arrangement.

15

## STATE OF THE ART

A large number of base station antenna installations have been necessary for the operation of cellular mobile telecommunication systems. Base station antenna arrangements have to be provided all over the area that is to be covered by the cellular communication system and how they are arranged among other things depends on the quality that is required and the geographical coverage, the distribution of mobile units etc. Since radio propagation depends very much on terrain and irregularities in the landscape and the cities the base station antenna arrangements have to be arranged more or less closely.

25

However, the installation of multiple antenna base stations has caused protests among others from an esthetical point of view both on the countryside and in the cities. Also, the construction of these antenna masts is expensive, e.g. because each antenna needs

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to be supplied with energy via a separate, expensive feeding cable.

The introduction of new base station antenna arrangements would be considerably facilitated if the infrastructure that already is in place could be better used. Today various examples of microstrip antenna elements which are capable of operating in two distinct frequency bands are known. However, it is difficult to avoid grating lobes when the frequency bands are not closely spaced.

#### OBJECTS OF THE INVENTION

An object of the invention is therefore to provide a multi frequency band antenna which does not present the above described problems. Another object of the invention is to provide an antenna which operates with different polarization states.

#### SUMMARY OF THE INVENTION

For these objects, the antenna arrangement in accordance with the invention is characterized in accordance with the accompanying independent claims.

Advantageous embodiments of the invention are described in the accompanying depending claims.

It is an advantage of the invention that the existing infrastructure already provided for the 800 or 900 MHz frequency band can be used also for new frequency bands such as about 1800 MHz or 1900 MHz. It is also an advantage of the invention that the antenna elements or the radiating elements are simple and flexible and enables a simple feeding etc. It is also an advantage that

dual polarization states can be supported with a high mutual insulation.

#### BRIEF DESCRIPTION OF THE DRAWINGS

- 5 The invention will be further described in the following in a non-limiting way under reference to the accompanying drawings in which:
- FIG 1a is a top view of a multi frequency antenna arrangement according to the invention,
- 10 FIG 1b is a schematical cross-sectional view of the antenna of Fig 1A along the lines 1b-1b,
- FIG 2a is a top view of an alternative embodiment of an antenna according to the invention,
- FIG 2b is a schematical cross-sectional view of the antenna of
- 15 FIG 2A along the lines 2b-2b,
- FIG 3a is a top view of a third embodiment of an antenna according to the invention,
- FIG 3b is a cross-sectional view of the arrangement of Fig 3A along the lines 3B-3B, and
- 20 FIG 4 is a top view of an array antenna according to the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

- Fig 1a and 1b illustrate a first example of a microstrip antenna
- 25 which is able to operate (receive/transmit) at two different frequencies or in two different frequency bands simultaneously. In Fig 1a, which is a top view of the antenna, a first radiating element 10 is arranged on top. The first radiating element 10 is here square shaped. A second radiating element 11 is arranged
- 30 below the first radiating element. The second radiating element is symmetrically arranged in a centralized manner under the first

radiating element. The first and second radiating elements 10, 11 respectively particularly comprise so called patch elements made of a conducting material, for example Cu.

5 The first patch element or radiating element 10 may be used for a communication system operating in frequency band of about 1800-1900 MHz whereas the second radiating element 11 may be used for a communication system operating in the frequency band of about 800-900 MHz. To facilitate this, the first and the second radiating  
10 elements have the appropriate effective resonant dimension respectively, in accordance with common practice, and in view of the effective dielectric constant of the dielectric material or medium, e.g. air which is used for insulating the first and the second patch.

15 In Fig. 1a, 1b the first radiating element 10 is mounted on two orthogonally arranged pairs of probes 12 that are responsible for energizing this element in two directions of polarization with a mutual angle of about 90°. The probes 12 extend via holes through  
20 the second element 11 and are mounted on a first layer 13 of a ground plane that also comprises a second layer 14. The ground plane layer 13 is provided with an electric feed network 15 for supplying the probes with energy in the two angles of polarization.

25 The lower, second radiating element, i.e. the low frequency band patch 11 is aperture fed from the second ground plane layer 14 via an aperture arrangement comprising slots 16 and 17. The outer slots 16 are oriented according to one of the polarization angles  
30 and the inner H-shaped slot 17 is oriented according to the other angle. The polarization is perpendicular to the long dimension of

the slots. The ground plane layer 14 is provided with an electric feed net 18 for supplying the slots with energy in the two angles of polarization. The above described slot configuration is only one example, many alternative slot configurations are possible, for example with crossing slots.

In alternative embodiments of the above described antenna, the second element may be energized by probes and this element may be provided with slot apertures for energizing the first element. The patches may have other shapes than square. The antenna may comprise any number of stacked elements for different frequencies, depending on the number of frequencies to be used in the antenna. The above described antenna module may be used in a multiple module array antenna.

In the above described embodiment, it is possible to feed both patches by means of the four probes 12. In this manner, a single power feed network may be used for energizing both patches.

Fig 2a and 2b show an alternative example of a microstrip antenna which is able to operate (receive/transmit) at two different frequencies or in two different frequency bands simultaneously. The same reference numbers have been used as in Fig. 1a and 1b to designate the corresponding details.

As in the first embodiment of the invention, in Fig 2a, which is a top view of the antenna, a first radiating element 10 is arranged on top. A second radiating element 11 is arranged below the first radiating element, symmetrically arranged in a centralized manner under the first radiating element.

The first patch element or radiating element 10 may be used for a communication system operating in frequency band of about 1800-1900 MHz whereas the second radiating element 11 may be used for a communication system operating in the frequency band of about 800-900 MHz.

In Fig. 2a, 2b the first radiating element 10 is mounted on two orthogonally arranged pairs of probes 12a that are responsible for energizing this element in two directions of polarization with a mutual angle of about 90°. The probes 12a extend via holes through the second element 11 and are mounted on a first layer 13 of a ground plane that also comprises a second layer 14. The ground plane layer 13 is provided with an electric feed net 15 for supplying the probes with energy in the two angles of polarization.

The lower, second radiating element, i.e. the low frequency band patch 11 is probe fed from the second ground plane layer 14 via probes 12b. Thus, the patch 11 is mounted on two orthogonally arranged pairs of probes 12b. One pair of probes 12b is oriented according to one of the polarization angles and the other pair of probes is oriented according to the other angle. The ground plane layer 14 is provided with an electric feed net 18 for supplying the probes with energy in the two angles of polarization.

In alternative embodiments of the above described antenna, the patches may have other shapes than square. The antenna may comprise any number of stacked elements for different frequencies, depending on the number of frequencies to be used in the antenna.

The above described antenna module may be used in a multiple module array antenna.



Fig 3a and 3b show a third example of a microstrip antenna in accordance with the invention which is able to operate (receive/transmit) at two different frequencies or in two different frequency bands simultaneously. The same reference numbers have been used as in Fig. 1a, 1b, 2a and 2b to designate the corresponding details.

As in the first embodiment of the invention, in Fig 3a, which is a top view of the antenna, a first radiating element 10 is arranged on top. A second radiating element 11 is arranged below the first radiating element, symmetrically arranged in a centralized manner under the first radiating element.

The first patch element or radiating element 10 may be used for a communication system operating in frequency band of about 1800-1900 MHz whereas the second radiating element 11 may be used for a communication system operating in the frequency band of about 800-900 MHz.

In Fig. 3a, 3b the first radiating element 10 is energized via aperture slots 16a and 17a in the second radiating element 11. The outer slots 16a are oriented according to one of the polarization angles and the inner H-shaped slot 17a is oriented according to the other angle. The element 11 is provided with an electric feed net 15a for supplying the aperture slots with energy in the two angles of polarization.

The lower, second radiating element, i.e. the low frequency band patch 11 is aperture fed from the ground plane 14 via slots 16b and 17b. The outer slots 16b are oriented according to one of the polarization angles and the inner H-shaped slot 17b is oriented

according to the other angle. The polarization is perpendicular to the long dimension of the slot. The ground plane layer 14 is provided with an electric feed net 15b for supplying the slots with energy in the two angles of polarization.

5

In alternative embodiments of the above described antenna, the patches may have other shapes than square. The antenna may comprise any number of stacked elements for different frequencies, depending on the number of frequencies to be used in the antenna.

10 The above described antenna module may be used in a multiple module array antenna. The second element 11 may be designed so that it is transparent with reference to the frequency of the first element 10, by e.g. incorporating FSS (Frequency Sensitive Surface) technics. In this way it is possible to have the slots  
15 for the two elements in a common ground plane.

Fig 4 shows an array antenna in accordance with the invention, which in this example comprises three groups of elements, but any number of such groups is possible. Two of the element groups are  
20 similar to the example shown in Fig. 1a and 1b. Between these two element groups is a third element group comprising an extra element 10 of the first high frequency type. This configuration may be suitable for avoiding grating lobes. The ground plane 14a preferably continues below the central group of elements, and the  
25 ground plane 14b of the central high frequency patch 10 preferably is arranged at the same level as the second elements 11 of the two lateral groups of elements. The central high frequency patch 10 is powered by probes 12.

30 The elements in Fig. 4 are oriented so that the polarization directions are  $\pm 45^\circ$  with respect to the long dimension of the

array. Any other directions, e.g.  $0^\circ$  and  $90^\circ$  may be used. The element groups of the array antenna may also be arranged in two dimensions.

- 5 In any of the above described antennas the two linear polarizations may be combined to form one or two circular polarizations.

10 The invention is of course not limited to the shown embodiments but it can varied in a number of ways only being limited by the scope of the claims. For example, any number of probes may be used in the antenna as long as they are symmetrically oriented around the axes of polarization. Rectangular, circular, oval or any other form of patches may be used.

## CLAIMS

1. A antenna arrangement for multi frequency band operation,  
5 comprising a first radiator element (10) for operation in a first frequency band and a second radiator element (11) for operation in a second frequency band, wherein said second element is arranged in a different plane from said first element,  
c h a r a c t e r i z e d i n  
10 that the first element (10) is placed so that it symmetrically overlaps the second element (11), that a conductive ground plane (14) is provided with means for feeding energy to the radiator elements (10, 11), and that the radiator elements are arranged for providing dual polarization.
- 15 2. An antenna arrangement according to claim 1,  
c h a r a c t e r i z e d i n  
that probe feeding is used for energizing the first radiator element (10).
- 20 3. An antenna arrangement according to claim 1 or 2,  
c h a r a c t e r i z e d i n  
that probe feeding is used for energizing the second radiator element (11).
- 25 4. An antenna arrangement according to claim 2 or 3,  
c h a r a c t e r i z e d i n  
that the probes (12) are arranged symmetrically around the two axes of polarization.

5. An antenna arrangement according to anyone of claims 2-4,  
characterized in  
that the probes (12) comprise two pairs of probes (12) arranged  
orthogonally in relation to each other for providing dual  
5 polarization.

6. An antenna arrangement according to claim 1 or 2,  
characterized in  
that the second element (11) is energized by means of an aperture  
10 arrangement (16, 17) in the ground plane (14).

7. An antenna arrangement according to claim 6,  
characterized in  
that for feeding energy to the second element (11), a first  
15 aperture arrangement (16) and a second aperture arrangement (17)  
are provided in the ground plane, the first aperture arrangement  
providing a signal having a first polarization and the second  
aperture arrangement providing a signal having a second  
polarization.

20 8. An antenna arrangement according to any one of claims 2-7,  
characterized in  
that the probes (12) are used as distancing means for positioning  
the first and the second element (10, 11).

25 9. An antenna arrangement according to claim 1,  
characterized in  
that the first element (10) is energized by means of an aperture  
arrangement (16a) in the second element (11).

10. An antenna arrangement according to any one of claims 1-9,  
c h a r a c t e r i z e d i n  
that the second element (11) is transparent with reference to the  
frequency of the first element (10).

5

11. An antenna arrangement according to claim 10,  
c h a r a c t e r i z e d i n  
that the two elements have a common ground plane (14).

10 12. An array antenna for multi frequency band operation,  
comprising a group of high frequency radiator elements (10) for  
operation in a first frequency band and a group of low frequency  
radiator elements (11) for operation in a second frequency band,  
wherein said low frequency elements (11) are arranged in a  
15 different plane from the high frequency elements,  
c h a r a c t e r i z e d i n  
that each low frequency radiator element (11) is arranged so that  
it is symmetrically overlapped by a high frequency element (10),  
that a conductive ground plane (14a) is provided with means for  
20 feeding energy to the radiating elements (10, 11), and that the  
radiator elements are arranged for providing dual polarization.

13. An antenna arrangement according to claim 12,  
c h a r a c t e r i z e d i n  
25 that probe feeding is used for energizing each high frequency  
element (10).

14. An antenna arrangement according to claim 13,  
c h a r a c t e r i z e d i n  
30 that probe feeding is used for energizing each low frequency  
element (11).

15. An antenna arrangement according to claim 13 or 14,  
c h a r a c t e r i z e d i n  
that the probes (12) are symmetrically placed around the two axes  
of polarization.

5

16. An antenna arrangement according to any one of claims 12-15,  
c h a r a c t e r i z e d i n  
that the probes comprise two pairs of probes (12) arranged  
orthogonally in relation to each other for providing dual  
10 polarization.

10

17. An antenna arrangement according to claim 12 or 13,  
c h a r a c t e r i z e d i n  
that each low frequency element (11) is energized by means of a  
15 respective aperture arrangement (16, 17) in the ground plane  
(14a).

15

18. An antenna arrangement according to claim 17,  
c h a r a c t e r i z e d i n

20

that for feeding energy to each low frequency element (11), a  
first aperture arrangement (16) and a second aperture arrangement  
(17) are provided in the ground plane, the first aperture  
arrangement providing a signal having a first polarization and the  
second aperture arrangement providing a signal having a second  
25 polarization.

25

19. An antenna arrangement according to any one of claims 13-18,  
c h a r a c t e r i z e d i n  
that the probes (12) are used as distancing means for positioning  
30 both types of elements (10, 11).

30

20. An antenna arrangement according to claim 12,  
c h a r a c t e r i z e d i n  
that the first element (10) is energized by means of an aperture  
arrangement (16a) in the second element (11).

5

21. An antenna arrangement according to any one of claims 12-20,  
c h a r a c t e r i z e d i n  
that the low frequency elements (11) are transparent with  
reference to the frequency of the high frequency elements (10).

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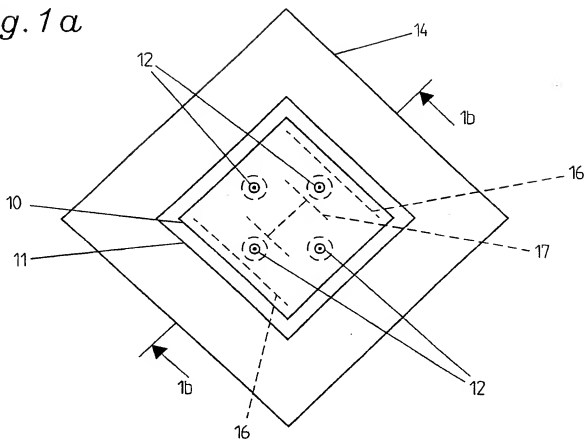
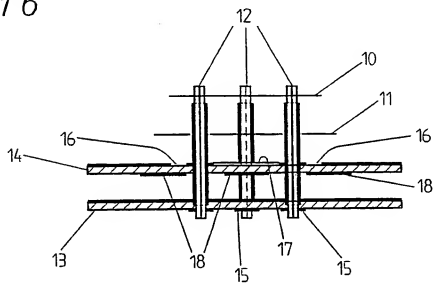
22. An antenna arrangement according to claims 21,  
c h a r a c t e r i z e d i n  
that the two types of elements have a common ground plane (14a).

15 23. Use of an antenna arrangement according to any one of the  
preceding claims as a base station antenna arrangement for mobile  
telecommunications.

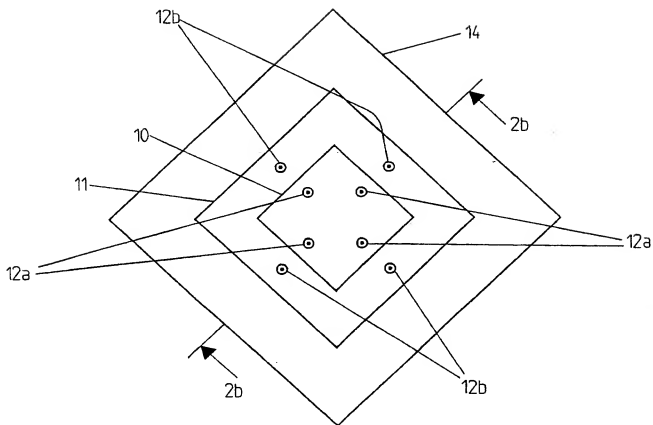
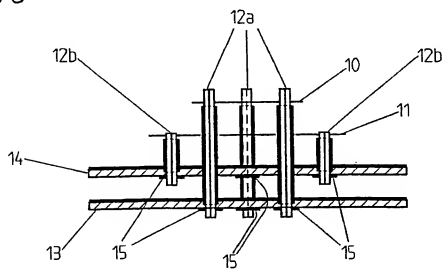
20 24. Use of a base station antenna arrangement in accordance with  
claim 23, c h a r a c t e r i z e d i n  
that the low frequency element operates in the 800-900 MHz  
frequency band such as e.g. NMT 900, AMPS, TACS, GSM or PDC and in  
that the high frequency elements operates in approximately the  
1800-2100 MHz frequency band such as e.g. DCS 1800, PCS 1900 or  
25 WCDMA.



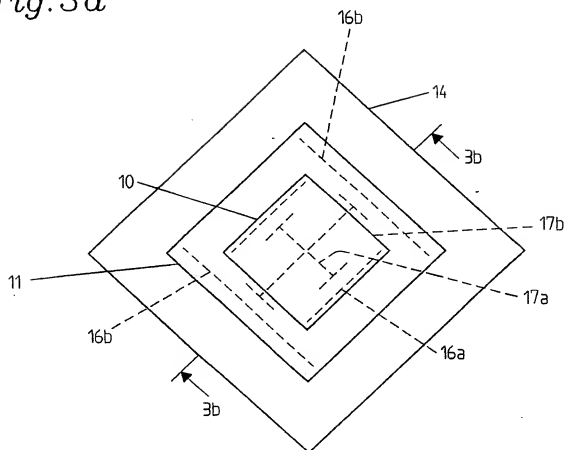
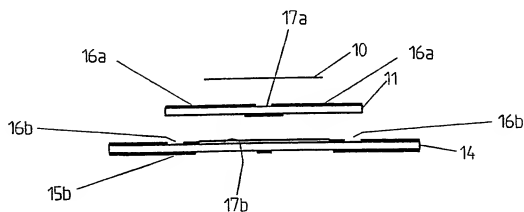
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*Fig. 1a**Fig. 1b*

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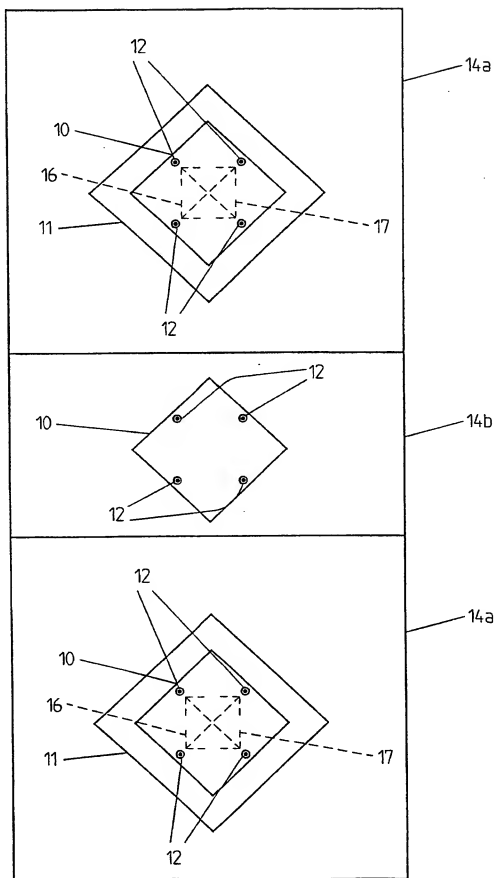
*Fig. 2a**Fig. 2b*

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*Fig. 3a**Fig. 3b*

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Fig. 4



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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE 99/01361

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 5/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9507557 A1 (UNIVERSITE DE LIMOGES), 16 March 1995 (16.03.95)  --	1-24
A	WO 9837592 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 27 August 1998 (27.08.98)  -- -----	1-24

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Date of the actual completion of the international search

28 January 2000

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INTERNATIONAL SEARCH REPORT  
Information on patent family members

02/12/99

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9507557 A1	16/03/95	AU 7617994 A	27/03/95
		CN 1114518 A	03/01/96
		DE 69411885 D,T	29/04/99
		EP 0667984 A,B	23/08/95
		SE 0667984 T3	
		FR 2709878 A,B	17/03/95
		JP 8503595 T	16/04/96
WO 9837592 A1	27/08/98	AU 2718197 A	19/11/97
		AU 6126998 A	09/09/98
		SE 508356 C	28/09/98
		SE 9700630 A	25/08/98